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SPECIFICATION

TITLE OF INVENTION: ~~INTERNALLY RESILIENT TIE FOR RAILROAD TRACK~~

TIE BLOCK RETAINER AND TIE BLOCK SLEEVE FOR RAILWAY TIES WITH INSERTED BLOCKS

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References Cited

U.S. PATENT DOCUMENTS

US-6,364,214 B1	*	6/2000	Sonneville	238/115
US-5,203,501	*	04/1986	Vanotti, Gerard	238/265
US-4,609,144	*	09/1986	Harmsen, John L.	238/1
US-4,728,032	*	03/1988	Beigl et al	238/382
US-4,616,395	*	10/1986	Farese et al	29/460
US-6,027,033	*	02/2000	Vanhonacker, Patric	238/382
US-2,719,676	*	10/1955	Prater	238/24
US-814,796	*	03/1906	McCallum	238/17
US-1,214,339	*	01/1917	McCourt	238/91

~~Jan H. Zicha, Upgrading Track and Roadbed for High Speed Operations, FRA Report DTFR-53-00-P-00377.~~

FIELD OF INVENTION

The present invention pertains to field of devices for supporting the rails of a railway.

BACKGROUND OF THE INVENTION

~~Significant and frequently critical part of track loading scenario is the reaction of the track to complex dynamic forces that reflect dynamic excitation of the vehicle that is generated by random irregularities of the track geometry and by variations of track stiffness. However, the conventional track design methods address these issues by time-independent static design approaches only. As a result, analyses of dynamic track/train interaction systems that capture interdependence of track and train components illustrated in Fig. 6 are not usually provided. In reality, dynamic forces from vehicles are not equal to the static reaction of the track as it is typically assumed by the contemporary state of the art in the track design field.~~

~~The devices invented by Mc Court, H.L.Prater, Harmsen, Vanotti, Beigl, Pratter, Vanhonacker, Farese, and Mc Callum provide constant static resiliency within the ties or on the ties. However, they do not address the actual dynamic response of track structure within the relevant dynamic track/train interaction system. In particular, these and similar devices lack dynamic dampening as the single and most critical dynamic track performance parameter directly related to the longevity of the track structure. Consequently, performance of these systems is incidental in spite of the resiliency they offer. In most of these and similar cases, intense correctional maintenance is necessary so that instances of significant acceptance in railway practice are rare. Only the Sonneville's LVT ballastless track system is dynamically designed and provides extraordinary dampening. Its installations in Euro-tunnel between France and United Kingdom, and on fourteen rapid transit and railroad track systems worldwide provide unprecedented reduction of track maintenance. However, the Sonneville's LVT system is restricted to ballastless track and used exclusively where concrete tunnel inverts and bridge slabs exist to provide firm structural foundation. This restriction simplifies the dynamic track/train~~

~~interaction system, eliminates variability of subgrade and foundation soils indicated in Fig. 6 and leads to a specific product named Low Vibration Track (LVT) produced by Permanent Way Corporation and Sonneville International Corporation. Sonneville excludes utilization of LVT system in ballasted track because the potential dynamic instabilities of foundation soils and their variability along the railway line lead to entirely different dynamic loading patterns. The invention of Internally Resilient Tie expands the application of the damper-like arrangement of independent block masses, proven by the Sonneville's LVT system on ballastless track, to the ballasted track category. This is facilitated by further development of the dynamic track/train interaction analyses and specialized software for solving the system shown in Fig. 6 demonstrated in its predecessor form in the referred FRA report DTFR-53-00-P-00377, Jan H. Zicha, Upgrading Track and Roadbed for High Speed Operations, January 30, 2001, and by advanced geotechnical exploration of foundation conditions of the track subgrade in the area of installation Internally Resilient Ties by specialized railway application of remote sensing methods of engineering geophysics.~~

~~While the Internally Resilient Ties resemble the devices patented by Mc Court, H.L.Prater, Harmsen, Vanotti, Beigl, Pratter, Vanhonacker, Farese, Mc Callum and Sonneville, they possesses improved properties not sought or expected by prior art. The Internally Resilient Ties are designed to resist actual dynamic loading forces acting in a ballasted track exposed to high speed and heavy axle load operational environments.~~

~~Particularly unsuccessful were attempts of prior art to reduce overall track stiffness by the increase of resiliency of the rail pad elastomer located directly under the rail. The rail pad is destroyed quickly by dynamic forces corresponding to high frequency vibrations if made sufficiently soft to be effectual in the reduction of the overall track stiffness. For this reason, hard~~

~~rail pads must be used. The nominal stiffness of a ballasted track equipped with standard concrete cross ties is then usually higher than what corresponds to the results of theoretical analyses and to empirical findings. The problem is particularly apparent on bridges and tunnel inverts with ballasted decks where the deterioration of track geometry is particularly intense. Internally Resilient Ties offer sufficient reduction of the nominal track stiffness without compromising hardness of rail pads.~~

~~All prior art concrete ties are lifted during the upward deflection of the rail that occurs at a certain distance from applied vertical wheel load. This upward movement is a major contributor to the deterioration of track geometry. This corresponds to the experience with rail float on common wooden ties with cut spikes. Wooden ties with properly installed conventional cut spikes used to secure rail in its position on the tie do not rise because a small space corresponding to the upward deflection of the rail is left between the bottom contact surface of the cut spike's overhang and the upper contact surface of the rail's foot. This space facilitates the rail float, the desired upward movement of the rail without lifting the tie off its contact plane with ballast. Internally resilient ties permit such a movement so that the rail float is no longer restricted to wood ties with cut spikes.~~

Ballastless railway track systems with independent booted blocks provide remarkable improvement of track/train interaction. Their installations in the Euro-tunnel between France and United Kingdom, and on twenty rapid transit and railroad track systems worldwide provide unprecedented reduction of track maintenance. This is accomplished by high levels of dynamic dampening and by the additional level of track resiliency inherent to the booted block concept.

In prior art, these advantages are restricted to the track systems with independent booted blocks where concrete tunnel inverts and bridge slabs exist to provide firm structural

foundations. However, similar booted blocks placed in railway ties (sleepers) have a potential to improve ballasted track as well. Some of the early devices patented by Mc Court, H.L.Prater, Harmsen, Vanotti, Beigl, Pratter, Vanhonacker, Farese, and Mc Callum could serve this purpose if technologically updated. However, the prior art does not restrict the vertical travel of the blocks at resonant frequencies, and does not facilitate lifting the ties by rails during the mechanized track installation and maintenance. The prior art would allow the blocks bounce uncontrollably at critical speed ranges, and the rail lifting during track installation and maintenance will withdraw the blocks from the ties, leaving the ties in place.

The spread of stray currents is a major contributor to the deterioration of utility lines and metal components of structures found near electrified railways, especially when direct current traction power is used. A major part of the stray currents' volume bypasses insulators through the water layer that exists on the surfaces of wet rail fasteners, insulators, tie blocks and ties, especially in rainy weather. The problem of the stray currents can be alleviated by using track insulation members with overhangs such as the ones commonly used on power lines that interrupt the surface water layer.

~~The spread of stray currents and decrease of electrical resistance that is needed for maintaining electrical track circuits appear on any track during rainy weather. Stray currents constitute major liability problems along electrified railway lines due to deterioration of neighboring utilities. While the insulators of track fastening devices are rigorously tested, the leakage occurs mostly through the water layer, dust and steel filings present on the surface of track components. This is because rail support assemblies of prior art do not involve insulators that would create dry areas under their overhangs, as it is the case in suspending power~~

~~distribution lines. The Block Sleeve provides an Internally Resilient Ties involve and overhang that creates dry area to interrupt the surface water layer.~~

~~Relatively light use of steel ties is attributed to their actual or perceived inadequate electrical insulation characteristics. The enhanced electrical insulation properties of Internally Resilient Ties may contribute to increased utilization of steel ties in the future.~~

~~The ballastless track systems that involve large blocks enclosed in rubber boots under the rails, such as the referred LVT system by Sonneville, facilitate large consumption of kinetic energy before it reaches the main vibration-abating insulator. However, the prior art blocks and additional components placed in ties of ballasted track are too light and small to offer comparable enhancement of vibration abatement. The vibrations radiating from heavily traveled lines equipped with ballasted track constitute major environmental problems in large cities regardless of the type of rail support used. The masses of independent blocks used in the Internally Resilient Ties are sufficient to result in the desired reduction of environmentally objectionable vibration spread.~~

ABSTRACT

Releasable tie block retainers are attached to the main body of a typical tie (1) with two inserted blocks (2)~~internally resilient tie, the tie case (1). The tie case (1),~~ The main body of a typical tie (1) includes two recesses to receive two independent tie blocks (2), preferably enclosed in rubber boots (4), equipped with standard rail fasteners (7) and protected with hard standard rail pads (5), wherein one tie block (2) is placed under each running rail (3). A bottom elastomer (6) is preferably used and located inside the boot under the tie block. ~~In a sequence of Internally Resilient Ties, the masses of the blocks (2) and the spring rates of bottom elastomers (6) can vary.~~ The tie block retainer assemblies, consisting of components (8) through (16), keep the tie blocks in the tie main body ~~case~~ (1) when the ~~Internally Resilient~~ tie is lifted by rails while allowing small movement of the blocks upward to provide rail float. Also, the block retainers restrict the vertical travel of blocks at resonant loading frequencies.

In order to decrease the current leakage, a non-metallic tie block sleeve (12) overhanging the edge of the tie block and sloping down is incorporated to insulate the rails. ~~A non-metallic insulating collar (12), overhanging the edge of the block and sloping down, is placed around the upper perimeter of each block.~~

~~BRIEF~~ SUMMARY OF THE INVENTION

~~Installation of Internally Resilient Ties in a ballasted track facilitates optimization of the dynamic track/train interaction regime according to a model illustrated on Fig. 6 to reduce track maintenance and to allow speed increases without costly deep soil replacements that are conventionally performed to remove naturally occurring variations of the track foundation. Unless the soils are exceptionally weak, this optimization is achieved by varying the spring rate of the bottom elastomer (6), by varying the mass of the independent block (2), and by choosing dimensions and materials of the assembly to provide high dynamic dampening.~~
~~One independent block (2) is placed under each rail (3) in a recess inside the tie case (1). The rail is attached to the independent block (2) by a threadless standard conventional fastener (7). The rail (3) is seated on a standard conventional elastomeric rail pad so that the mass of the block (2) is placed between two elastomers what results in its dynamic damper action. Dynamic forces corresponding to high frequency vibrations are abated by a standard rail pad of sufficient and constant hardness while the stiffness variations and nominal track stiffness adjustment of the assembly are performed at the elastomeric bottom pad (6) under the block in the context of the broader dynamic track/train interaction control. This feature has a potential of optimizing nominal stiffness of a track equipped with concrete ties and eliminating the increased track maintenance intensity experienced on continuously ballasted bridges and tunnel inverts.~~

~~The independent block (2) is prevented~~ Releasable block retainer assemblies (8 through 16) prevent the ~~independent~~ tie block (2) from being pulled out of the main body of the tie ~~case~~ (1) ~~by block retainer assemblies (8 through 16)~~ when the ~~Internally Resilient~~ tie is lifted by rail (3) during track installation and maintenance. Also, tie block-retaining assemblies restrict its vertical movement at resonant frequencies. However, a small movement is allowed and elastic

restrain ~~are~~ is provided to facilitate rail float. The rail float allows a slight upward movement of the rail with attached blocks during the uplift phase of the rail deflection, while leaving the main body of the tie (1) in place. ~~so that the intensity of track maintenance is reduced.~~ The interface of the tie's bottom plane and the supporting ballast thus remains undisturbed so that the track geometry deterioration and track maintenance intensity are reduced. The accuracy of the vertical travel control is enhanced by the optional features (14) and (15) that provide controllable mating surfaces on the top of the retained tie blocks (2).

The releasing and retaining portion of the tie block retainer is thread-less to eliminate maintenance-intensive loosening of corroded threaded components.

The pin (11) and retaining elements of the tie block retainer (9) and (10) can be readily removed to allow a complete withdrawal of tie blocks and boots from the tie for quality control, maintenance, or replacement of tie blocks, boots and otherwise inaccessible elastomers

The tie block sleeve is an optional ~~A~~ non-metallic collar (12) that is attached on the top of the block (2) to provide a dry area under its overhang. The surface leakage of stray electric currents is ~~thus~~ interrupted by the dry area.

The tie block retainer is designed to span over the tie block sleeve.

~~Large enough masses of independent blocks (2) are used to facilitate absorption of significant portion of kinetic energy of environmental vibrations before the bottom elastomeric pad (6) is mobilized so that unprecedented levels of vibration insulation of ballasted track are available to solve relevant environmental way-side problems in populated areas.~~

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Fig. 1 includes elevation, crossection and plan view of tie block retainers and tie block sleeves installed on a concrete tie with ~~Internally Resilient Tie with Independent Booted~~ tie blocks ~~and Concrete Case constructed in accordance with the present intention and~~ for use on ballasted track.

Fig. 2 includes elevation, crossection and plan view of tie block retainers and tie block sleeves installed on a steel tie with ~~Internally Resilient Tie with Independent Booted~~ tie blocks ~~and Steel Case constructed in accordance with the present intention and~~ for use on ballasted track.

Fig. 3 includes Detail of Section I-I and the tie block retainer assemblies cast in a concrete tie ~~case~~, and the tie block sleeve.

Fig. 4 includes Detail of Section II-II and the tie block retainer assemblies installed on a steel tie ~~case~~, and the tie block sleeve.

Fig. 5 includes plan view relevant to the tie block retainer assemblies, and the tie block sleeve.

~~Fig. 6 includes Dynamic Track/Train Interaction System – Model for One Axle~~

DETAILED DESCRIPTION OF THE INVENTION

~~The internally resilient tie is based on application of specialized design process of advanced dynamic track/train interaction analysis demonstrated in the enclosed report Upgrading Track and Roadbed for High Speed Operations by Jan H. Zicha, DTFR 53-00-P-00377, dated January 30, 2001. This process facilitates an expansion of the advantages of added controlled sprung masses of independent blocks to ballasted track. These advantages have been already demonstrated in the category of ballastless track types with independent booted blocks, such as Sonneville's LVT system that are exposed to different loading regime due to the presence of firm structural foundations. While the appearance of internally resilient tie is similar to prior art, it serves different function and the actual conditions of the track foundation and the nature of ballasted track are reflected in a different process of design, analyses and installation of sequentially installed internally resilient ties. Wherever foundation conditions vary, the unprecedented options to vary spring rates of the track by varying stiffness of the bottom elastomeric pad (6) with or without variations of the masses of the blocks (2) are available to bring about advantages described in the Background of Invention and Brief Description of the Invention.~~

~~Large components of the internally resilient tie have been described in the Abstract and Brief Description of the Invention and are apparent from enclosed Figures 1 and 2.~~

The tie block retainer (8) is attached to the main body of a typical tie ~~concrete tie case~~ (1) by its anchoring protrusion cast into the concrete of the tie case (1) shown on Fig. 1. The tie block retainer (16) is attached by bolted steel to steel connection to the steel tie case (1) shown on Fig. 2. Except for this connection, the block retainer is thread-less. Flat leaf springs (9) and (10) are inserted into a curved slot in a metallic insert (8) and (16). During installation, the lower

leaf spring (9) is inserted first and then the upper leaf (10) is driven in. It deflects and causes the leaf (9) to deflect as well. The leaves (9) and (10) stay within the slot by due to the ~~thus~~ introduced pre-load. An eventual shifting of the leaves that would loosen the plates is prevented by the pin (11) inserted into the aligned holes in the leaves (9) and (10) and in shoulders (8) and (16). For enhanced accuracy, the contact surface on the tie block's top (2) can be lowered or raised by inserting an adjustable thickness member (14) ~~of an adjusted depth~~ into the slot created by two members (15).

The pin (11) and the leaf springs (9) and (10) can be readily removed to allow a complete withdrawal of the tie block from the tie for quality control, maintenance or replacement.

Large components of the ties that support the block retainers, and the withdrawal of tie blocks, boots and elastomers have been described in the Abstract and Brief Description of the Invention. Also, they are apparent from Figures 1 and 2.

CLAIMS

25. (amended) ~~The internally resilient railroad tie of claim 23~~ A tie block retainer for a concrete tie using a releasable device for retaining tie blocks (two each) inserted in a concrete tie, wherein the tie block retainers comprises of a cast iron inserts equipped with an anchor member for anchorage in the said concrete tie, and with a curved slot at the top of the anchor member to receive leaf springs that are secured by a vertical pin inserted into aligned holes on top of the said anchor member.

26. (amended) ~~The internally resilient railroad tie of claim 24~~ A tie block retainer for a steel tie using a releasable device for retaining the tie block (two each) inserted in a steel tie, wherein the tie block retainers comprises a cast iron insert equipped with an anchor member having a threaded extension for attachment to said steel tie, ~~said anchor member having~~ and with a curved slot at the top of the said anchor member to receive leaf springs that are secured by a vertical pin inserted into aligned holes on top of the said anchor member.

27. (amended) ~~The internally resilient railroad tie~~ A tie block retainer of claim 25 wherein a space is left between the bottom surface of the bottom leaf spring and the corresponding contact surface of the tie block inserted in a concrete tie so that the upward movement of the rail occurring at a certain distance from applied wheel load is facilitated without lifting the concrete tie from ~~ease of the internally resilient railroad tie and without any other interference with~~ its contact plane on ballast.

28. (amended) ~~The internally resilient railroad tie~~ A tie block retainer of claim 26 wherein a space is left between the bottom surface of the bottom leaf spring and the corresponding contact surface of the tie block inserted in a steel tie so that the upward movement of the rail occurring at a certain distance from applied wheel load is facilitated without lifting the

steel tie from ~~ease of the internally resilient railroad tie and without any other interference with~~ its contact plane on ballast.

29. (amended) ~~Block of internally resilient tie of claims 23, and 24 comprising~~ A tie block sleeve made of electrically insulating material attached to the top of a tie ~~the~~ block that is inserted in a railway tie in such a manner that the said block sleeve provides an overhang continuous around the said tie block, and wherein the said tie block sleeve protrudes outward and slopes downward in such a manner that the bottom side of the said overhang is protected from directly falling rain water.